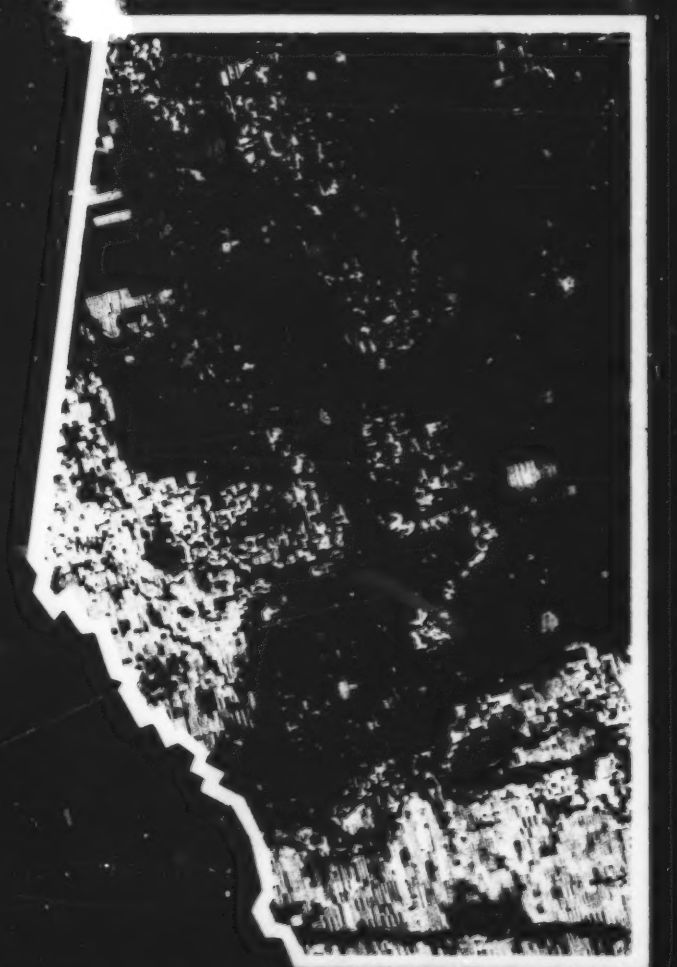
REMOTE SENSING

Alberta's Rangelands — A Users Guide



Alberta

Revised Edition

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MONITORING RANGELANDS IN THE MIXEDGRASS PRAIRIES OF SOUTHERN ALBERTA WITH RANGELAND ENHANCED LANDSAT IMAGERY: A USERS GUIDE

REVISED EDITION 1984

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USERS GUIDE

This publication is for practical use by rangeland managers. A revision in 1984 was warranted due to changes in image product specifications and ordering procedures. Complete details of the Alberta Rangeland Study, including references, are contained in Alberta Rangeland Assessment Using Remotely Sensed Data, Research Report 83-1, R.J. Brown, F.J. Ahern, K.P.B. Thomson, K. Staenz, J. Cihlar, C.M. Pearce and S.G. Klumph, published by and available from the Canada Centre for Remote Sensing, Energy, Mines & Resources Canada, 2464 Sheffield Road, Ottawa, Ontario, K1A 0Y7.

COVER PHOTO

Rangeland near Vauxhall, Alberta from Landsat, 13 September, 1981.

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INTRODUCTION

In Alberta, large areas - millions of hectares - of grazing land are privately owned or are Crown lands leased to the public. The Crown grazing lands in the settled areas are managed and regularly inspected by the Public Lands Division, Alberta Energy & Natural Resources. To regularly survey these vast areas of rangeland requires an extensive program of ground inspection.

In 1980, the Public Lands Division of Alberta Energy & Natural Resources, the Canada Centre for Remote Sensing of Energy Mines & Resources Canada, and the Alberta Remote Sensing Center of Alberta Environment began a joint project to evaluate Landsat (resource satellite) data for monitoring range conditions in Southern Alberta.

The objective was to develop a special Landsat image with which to rapidly, at low cost, monitor range use and condition and identify over-utilized ranges in Southern Alberta. The Landsat images were to provide coverage of large rangeland areas economically, be easily used with a minimal degree of interpretation training, and be readily available on a continuous basis to range managers. Secondary objectives were to determine if the satellite data could be used to: (1) estimate the aboveground plant biomass; (2) separate the biomass into green vegetation and brown litter and carry-over; (3) differentiate the green biomass into grasses, forbs, and shrubs; and (4) identify dominant species in the biomass.

Private landowners in the region indicated their interest and actively participated throughout the project. Their advice and assistance in developing a practical and useable product were invaluable.

This report summarizes the major aspects and results of the project and includes a guide for interpreting the rangeland enhanced Landsat imagery.

BACKGROUND

Remote sensing is the detection, identification and evaluation of objects by aerial sensing devices. One device is a resource satellite, Landsat, that repetitively acquires, on cloud-free days, earth surface data in green (band 1), red (band 2) and near-infrared (bands 3 and 4) portions of the electromagnetic spectrum. Data of Canada are acquired on repetitive orbits and transmitted by Landsat to the Prince Albert Satellite Station and converted from electronic signals to photographic images and computer tapes. The images and tapes are in the public domain - anyone may buy reproductions. Information on Landsat and its products may be obtained from the Alberta Remote Sensing Center and the Canada Centre for Remote Sensing (CCRS).

Landsat records the amount of light reflected from the earth's surface, including that from vegetation. Variations in plant size, leaf morphology and orientation, pigmentation, and internal physiology contribute to different reflectance patterns of individual plant species. These differences are pronounced in the near infrared wavelengths. Topography and local weather patterns contribute to differences in species vigour and development over a rangeland area. Surface soil color and soil moisture also affect reflectance from the ground surface: light-colored dry soils reflect more light in all wavebands than do dark or wet soils.

DESCRIPTION OF STUDY AREA

Much of Southern Alberta is characterized by native grasslands with a cover of short to medium grasses and low forbs and shrubs. The native grasslands are divided into two main regions: the Mixedgrass Prairie, in which the project took place, and the Fescue Grasslands (Figure 1).

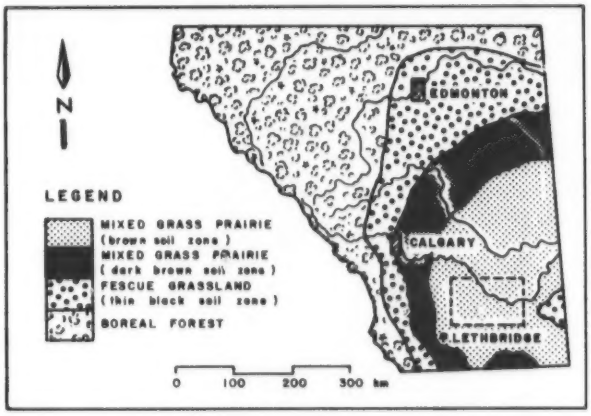


Figure 1. Location of Study Area in Southern Alberta.

The Mixedgrass Prairie is associated with the Brown and Dark Brown soil zones of Alberta which have developed from glacial tills under the semi-arid conditions of low precipitation and high evaporation. Well-drained Brown Chernozems, predominantly sandy loam in texture, are the dominant soils on undulating and gently rolling topography. Solonetzic soils, characterized by a higher sodium content and poorer structure than the chernozems are found in the Mixedgrass Prairie.

Needle-and-thread and porcupine grass dominate the Mixedgrass Prairie on medium to coarse-textured soils in combination with northern wheatgrass, blue grama grass and junegrass. Pasture sage, sagebrush, and thread-leafed sedge are important forbs and shrubs. Western wheatgrass, blue grama grass and cacti are prevalent on solonetzic soils. Sandgrass, rice grass and rose are characteristic species of sandplains and stable dunes. Western snowberry, chokecherry, saskatoon berry, and other shrubs are found on protected slopes and in depressions.

Vegetation growth in the Mixedgrass Prairie begins relatively early in the spring. The grasses have adapted to summer droughts by early dormancy so that by the end of July most of the vegetation may be dried. The amount of forage on rangelands may vary significantly depending on the productivity of the site and seasonal precipitation. Heavy grazing reduces the forage yield of the vegetation by eliminating the more desirable mid-grasses, such as needle-and-thread, porcupine grass and wheatgrasses. Sandberg's bluegrass and many species of forbs and shrubs become more prevalent.

METHODS

During the 1980 and 1981 growing seasons, field trips were made to each of the grazing leases chosen by the Public Lands Division for this project (see Figure 2).

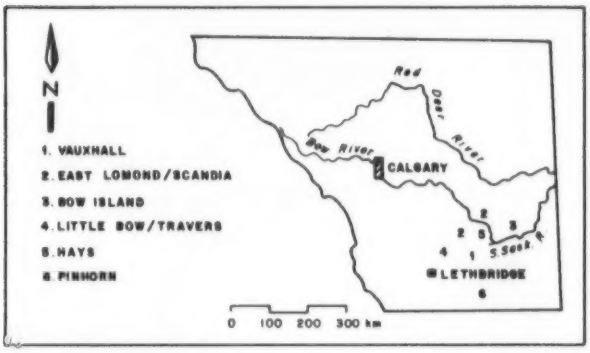


Figure 2. Location of Grazing Leases.

Based on a review of work carried out on other rangelands in Canada and the U.S. and the professional knowledge and experience of range managers and scientists in Alberta and Saskatchewan, it was decided that visual interpretation of Landsat images, enhanced for rangeland applications, would be practical for evaluating and monitoring range use. Scientists of the Canada Centre for Remote Sensing and the Alberta Remote Sensing Center were accompanied by the manager responsible for the particular lease. The most recent Landsat image for each lease was interpreted in the field with the rangeland manager and compared with actual ground conditions.

Vegetation is probably the most visible ground feature detected by the satellite. Since information on the vegetation is of great significance to the range manager, the type and amount of vegetation and seasonal changes were the parameters considered when interpreting the imagery. Ground sampling included spectral reflectance measurements, estimates of foliage cover and vigour, the ratio of green to brown vegetative material, the amount and color of exposed soil and current grazing use. Vertical and oblique ground photographs were taken of ranges sampled, for a permanent visual record.

During the project, various types of Landsat image products were developed and evaluated. Those with promise, based on evaluation for practical use by range managers, were improved; those lacking promise were discarded. The most useful Landsat product was found to be the enhanced image in which the rangeland vegetation was brought out in greater detail than other ground features. This was done by CCRS scientists using a computer technique developed for rangeland image enhancement.

A number of photographic products of various sizes, scales and color renditions were processed from the specially enhanced image negative and assessed in the field. The best end product for interpretation, convenience and economy was an enlargement of a 32 km x 22 km (20 mi. x 14 mi.) sub-image to a scale of approximately 1:140,000 on an 8" x 10" sheet of color film. This sub-image could be anywhere on the cloud-free portion of a Landsat image. For coverage of larger areas, a sub-image of 116 km x 78 km (72 mi. x 48 mi.) (1:500,000) was also formatted for 8" x 10" film.

IMAGERY INTERPRETATION

Viewing imagery recorded by Landsat from hundreds of kilometers in space, at small scale, not oriented north to south, and with ground features different in color than normally seen (see Figure 3) requires new interpretation techniques. Ground photography or photography taken from an aircraft at an oblique angle show objects in a familiar view. The satellite image shows objects in an unfamiliar form - the plan view. With practice and by applying interpretation techniques to this "space view", the identification and significance of objects becomes evident (See Figures 4 and 5).

A methodical system of relating each object on the image to "interpretation factors" provides the best results. Each object should be studied by applying these factors in sequence until its identification and evaluation is achieved. The interpretation factors of most value (there are others) in interpreting rangeland enhanced imagery for monitoring rangelands are:

Size - the comparative size of an object or area to other objects in the same image.

Shape - generally, natural objects are characterized by their irregular shape. Cultural (man-made) objects are usually regular in shape (e.g. linear, rectangular).

Pattern - the patterns formed by natural and cultural features - rangelands, drainage, irrigation systems, roads, section lines and farming practices - are good indicators of their identity.

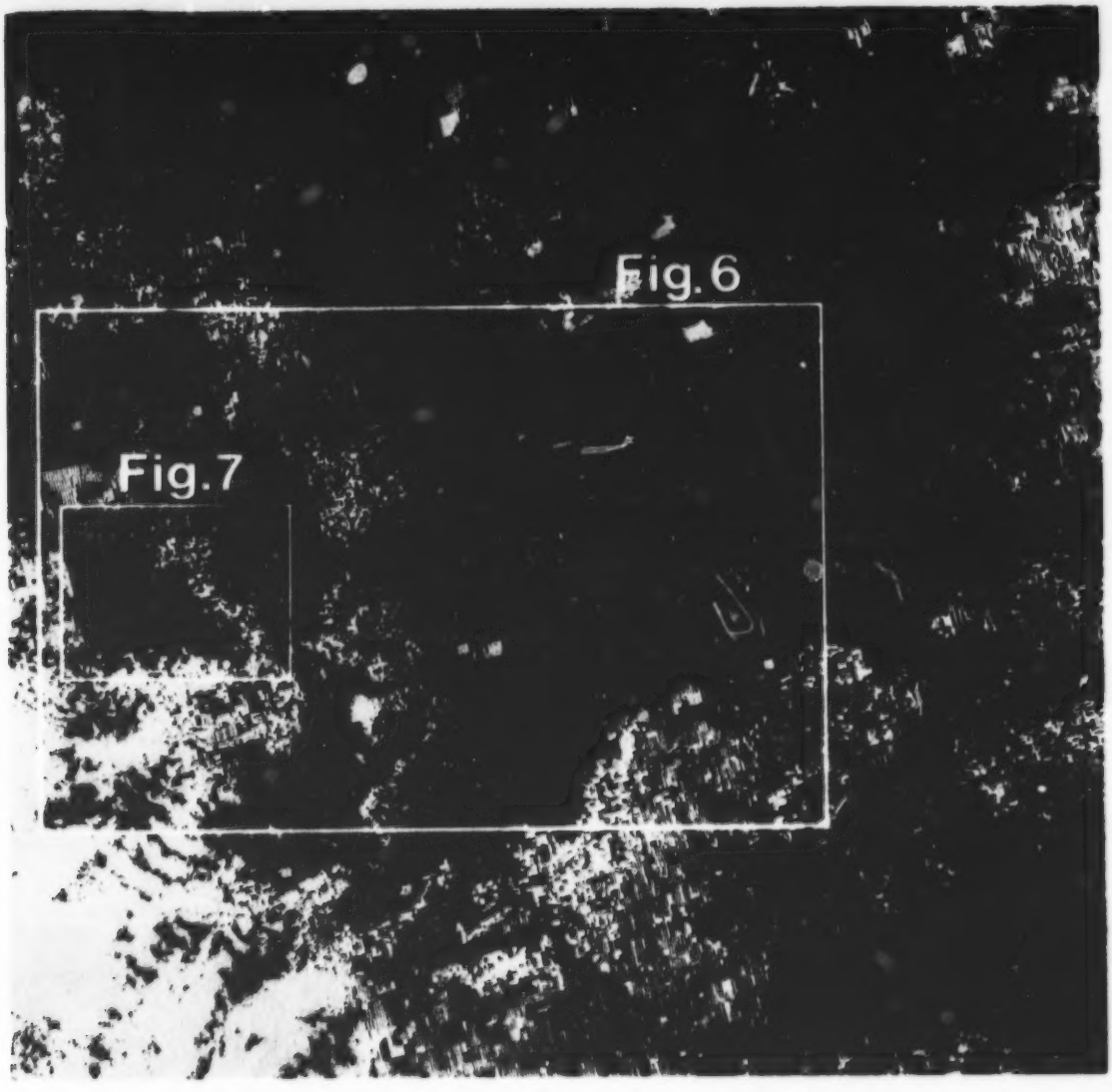


Figure 3. Conventional Landsat Scene, 1 September, 1983.

A conventional Landsat scene portrays some 12,000 square miles (30,000 sq.km.), or approximately 115 miles by 100 miles on the earth's surface.

This image of southern Alberta has been cropped slightly, but still represents over 80% of a conventional scene - 100 miles per side. North is to the top left.

Lake Newell is to the left edge of the scene; the Suffield Block, with light cloud cover is at the upper right. Cloud cover and shadow obscure the land in the lower left corner. The following color legend may assist with basic image interpretation:

Red - irrigated farmland. Some reddish areas to the lower right corner represent the forests on the lower slopes of the Cypress Hills.

Green, Blue and White strips - dry land farming with either ploughed stubble, bare ground or ripe cereal crops present.

Large Green-toned areas - rangeland.

Black - clear water, cloud shadow and burn scars (examine Suffield closely).

Superimposed on the image are the areas portrayed on the Rangeland Enhancements, Figures 6 and 7.

Associated Features - objects may be identified by studying their relationships with other objects which together make up a recognizable feature.

Color - the colors on the rangeland enhanced image are the predominant factors in interpreting rangeland. But the colors are artificial, not those usually associated with features. Vegetation, depending upon conditions, can be displayed in various colors. The same area or feature will vary in color tone among images acquired at different times of the year and may even vary between photo reproductions of the same image, particularly when printed in publications. It is emphasized that interpretation must be based on the color and tonal differences of objects on a particular image and not on color comparisons between different images.

Further, rangeland enhancements made from Landsat 4 data tend to be predominantly green, especially fall scenes, unlike those from other Landsats. This factor makes it critical that TONES rather than colors be the criterion for interpretation.

Spring and early summer imagery from all Landsats have special colorations (pink) to brown) due to the new growth of green grasses and forbs and cannot be readily interpreted with a "fall" color key. Early-season imagery have special applications more related to water distribution than to rangeland quality assessment. These aspects are summarized at Figure 8.

Generally, most of the colors on the rangeland enhanced Landsat images for the Mixedgrass Prairie can be interpreted as follows:

- pink to red: (Landsat 4, orange-rust)	sparse to dense vegetation cover that is dominated by green grass and/or broad-leafed plants.
- dark blue: (Landsat 4, dark green)	lightly grazed ranges in excellent condition, with a dense cover of native grasses or crested wheatgrass with a high proportion of carry-over (last year's growth; thatch). **Carryover, its presence or absence, is the prime indicator in range quality assessment.**
- medium blue-grey: (Landsat 4, mid-green)	moderately grazed ranges in fair to good condition dominated by native grasses.
- light blue-grey: (Landsat 4, light green)	heavily grazed ranges in poor condition with a sparse cover of vegetation, or tame pastures planted to Russian wild rye.
- light grey: (Landsat 4, grey-yellow and light blue)	ranges with a very sparse vegetation cover on steep slopes, the tops of knolls, and gravelly sites.
- white: (Landsat 4, yellow-white)	areas of alkali and bare sandy soil.
- very dark blue or black:	clear water bodies, usually identifiable by their shape, burn scars and shadow.

INTERPRETATION OF BOW ISLAND AND VAUXHALL GRAZING LEASES

The Bow Island grazing lease (Figure 4) and the Vauxhall grazing lease (Figure 5) are examples of rangeland enhanced Landsat 2 imagery. Being specially enhanced for rangeland study, the clarity and color renditions of other ground features, such as cropland and irrigated areas, are degraded.

The ground photographs are keyed to specific objects, annotated with a letter JUST BELOW the object.

Bow Island Grazing Lease - See Figure 4.

Most of the Bow Island grazing lease is located north of the South Saskatchewan River; dryland and irrigation farming are south of river. The town of Bow Island is off the bottom of the image. Large areas of the native range in the eastern parts of this lease have been replanted to tame pasture species dominated by Russian wild rye and crested wheatgrass. As on the Vauxhall imagery, lightly used range in good to excellent condition is dark blue and medium blue-grey and the more heavily used ranges in fair to poor condition are light blue-grey.

Figure 4a. White with light blue-grey mottles or stripes: newly planted Russian wild rye with invasion of Russian thistle between the rows.

Figure 4b. Dark blue: vigorous cover of Russian wild rye and crested wheatgrass.

Figure 4c. Light to very light blue-grey with white mottles: poor cover of Russian wild rye and crested wheatgrass. Note the large areas of bare light-colored soil between the grass plants.

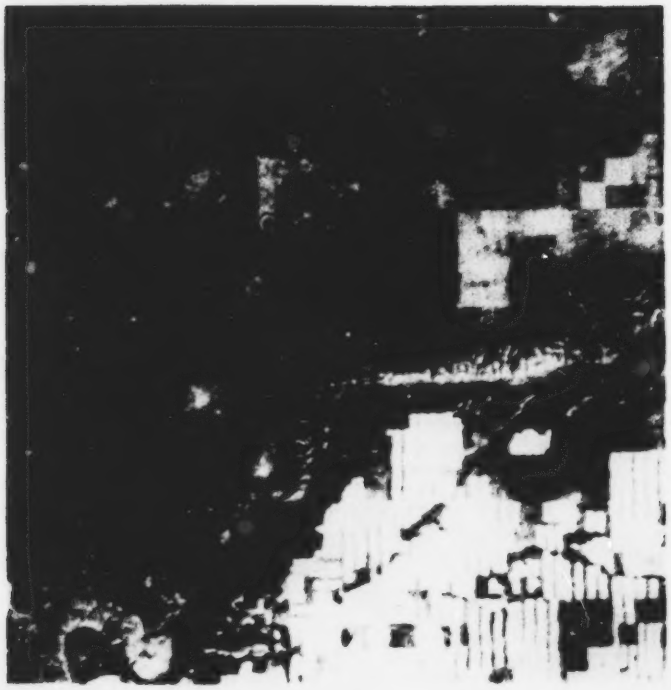
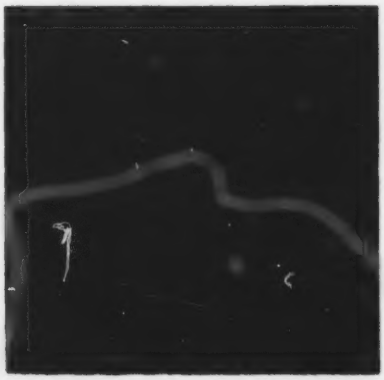
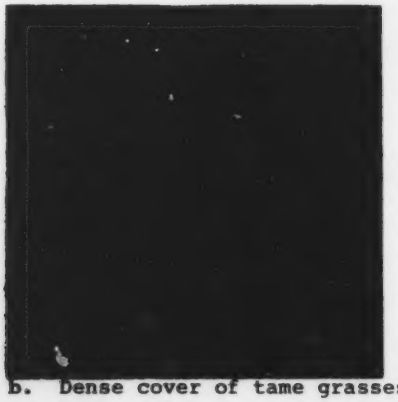


Figure 4. Enlarged portion of rangeland enhanced image. Bow Island Grazing Lease, September 12, 1981.

a. Young Russian wild rye.



c. Poor cover of tame grasses.



b. Dense cover of tame grasses.

Vauxhall Grazing Lease - See Figure 5.

On this enhanced scene, the town of Vauxhall is located just below the top left, Scope (Hays) Reservoir near the top right and the Oldman River at the bottom. The lease is surrounded by irrigated lands: red - crops; white - cultivated areas with stubble; light green - recent summerfallow; and circles - pivot irrigation with colors as for other irrigated crops. The Vauxhall grazing lease is dominated by native ranges in poor to excellent condition.

Figure 5a. Dark blue: lightly grazed native range in excellent condition dominated by a dense cover of native mid-grasses (needle and thread, june grass). Carry-over and litter obscure the green growth and underlying light-colored soils.

Figure 5b. Medium blue-grey: moderately to heavily grazed native range in fair condition. Small red areas: moist depressions.

Figure 5c. Light blue-grey: very heavily grazed native range in poor condition with a sparse cover of native grasses. Small grey-to-white areas: bare sandy soil.

Figure 5d. Pink to red: moist depressions supporting vigorous growth of broad-leafed plants.

Figure 5e. Pink to blue-grey: heavily grazed native range. With continuous heavy grazing, broad-leafed plants (the pink tones) invade the native grasses.

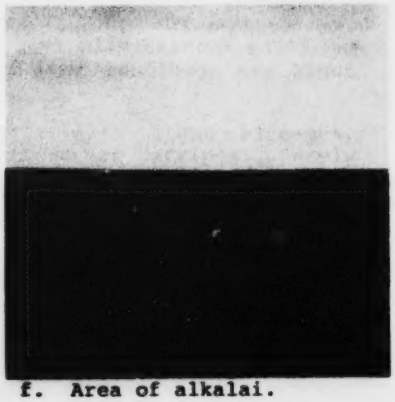
Figure 5f. White: erosion of upper soil horizons associated with solonetzic soils.

Figure 5g. Thin straight white line: pipeline, with invasion of thistle. Depending on the regrowth of vegetation may appear different in tone from the surrounding area.

Figure 5h. Dark blue strips: dense cover of crested wheatgrass planted in strips to improve the productivity of the native range.

a. Range in good condition.

d. Moist depression.



f. Area of alkalai.

b. Heavily grazed.
Fair condition.

c. Very heavily grazed.
Poor condition.

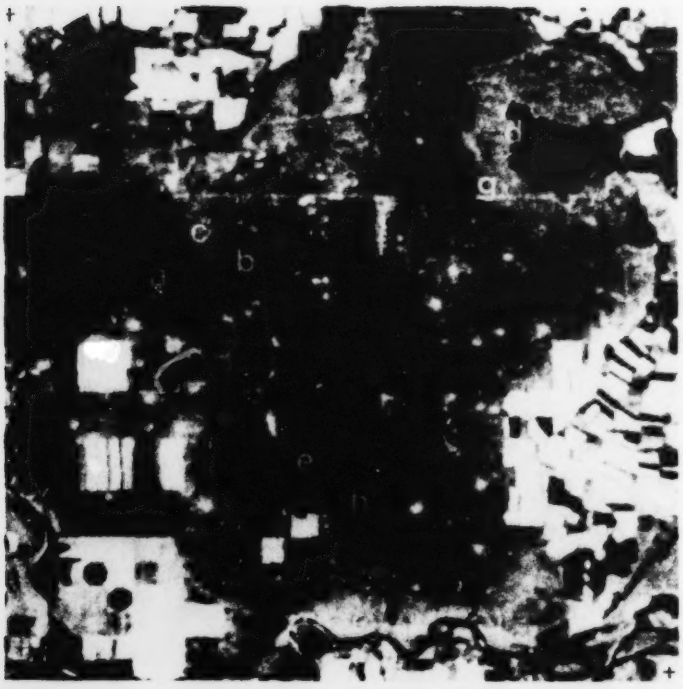
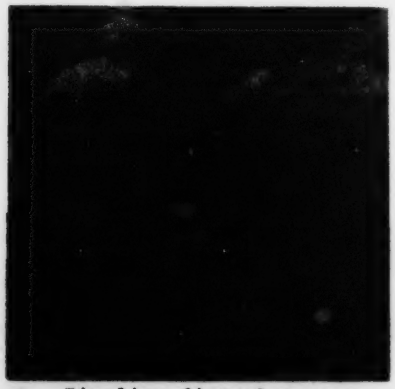


Figure 5. Enlarged portion of rangeland enhanced image.
Vauxhall Grazing Lease, September 12, 1981.

e. Heavily grazed. Invasion
of broad-leafed plants.



g. Pipeline disturbance.

h. Improved range. Strips
of planted wheatgrass.

Figure 6.

Rangeland Enhancement Product, 1:500,000 (8 mi./in.)

This scene represents approximately one-third the area of a normal Landsat frame. It is useful in assessing **regional** trends in range condition and land use. For a larger scale, and more localized perspective, see Figure 7.

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Figure 7.

Rangeland Enhancement Product (Fall), 1:140,000 (2¼ mi./in.)

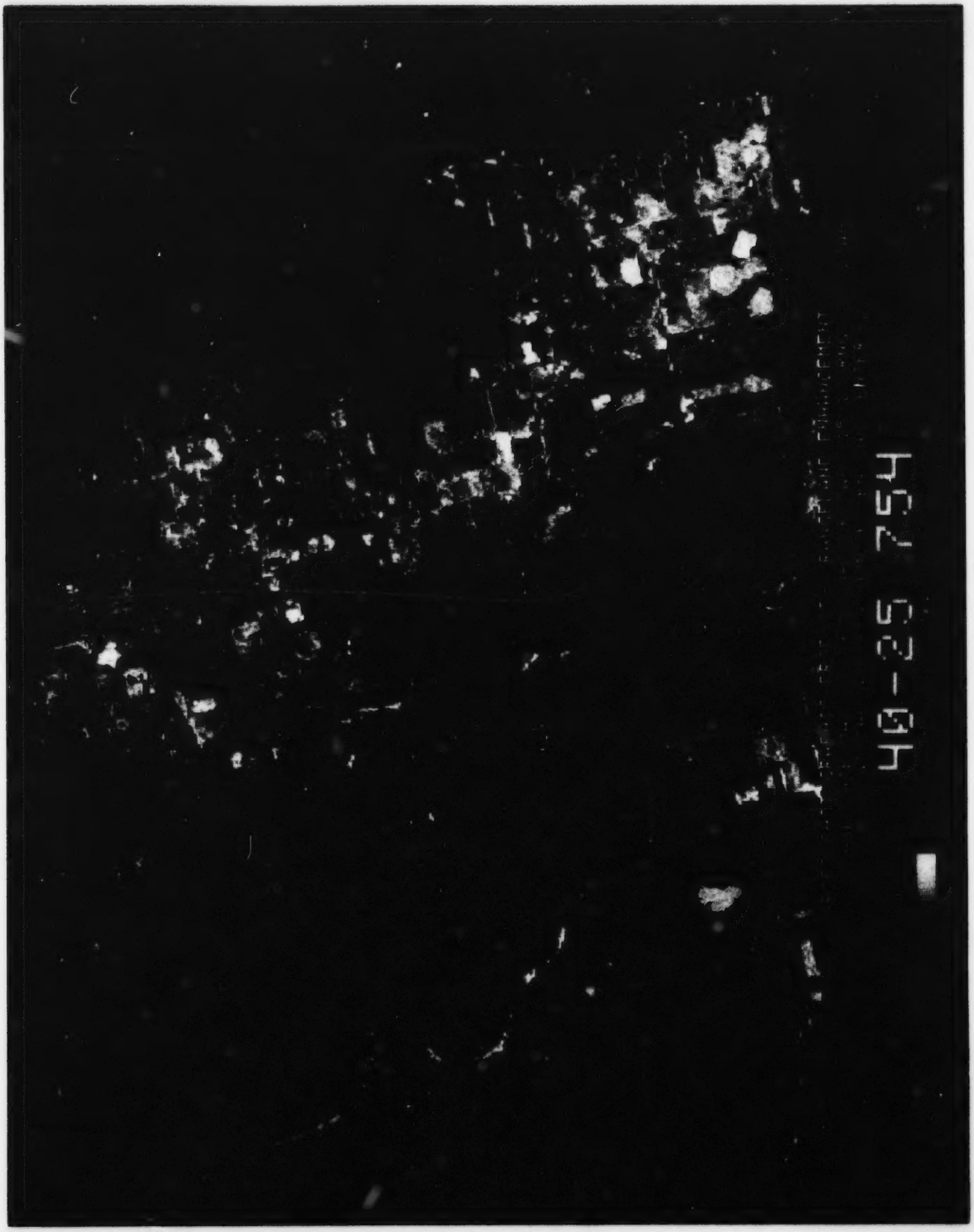
This scene is almost enlarged to the maximum effective scale - individual pixels begin to give it a blocky appearance. Fields of dense planted grasses and those with great amounts of carryover show dark green. Clouds and shadow obscure the ground along the lower edge. The East Lomond pasture is to the left of the image, west of the Bow River.

49-25 254

Figure 8.

Rangeland Enhancement Product (Spring), 1:140,000 (2¼ mi./in.)

The dramatic color shift to pink-brown is caused by the reflectance of the newly-emerged green grasses in the late spring. As they mature then brown, their colors on the image will adopt the "fall" scene appearance. A comparatively higher water table in the spring makes the lakes and sloughs more apparent (note the differences in Lake Newell's southern shoreline between Figures 7 and 8). Many dugouts and low moist areas on the East Lomond pasture show as small pink blotches. Many of these spots are connected by faint pink streaks - indications of spring streamflow, or rather the lush vegetation that grows in these moist depressions. As with the "fall" image, fields with extensive carryover are generally darker green.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SUMMARY

This project, jointly conducted by the Canadian and Alberta governments, led to the development of a special enhancement for Landsat images which provides useful information to the managers of Mixedgrass prairie ranges in Southern Alberta. The manager can interpret these repetitively acquired images which, if applied to his management plan, makes these enhanced images a very useful tool not previously available.

It is possible to quickly and accurately assess cattle grazing patterns over large range areas and pinpoint locations that may need corrective management. Grazing patterns and problem areas can be continually monitored using subsequent images.

In the Mixedgrass Prairie, it appears that one or two images per growing season are sufficient for management information. The range managers in Southern Alberta involved in this project preferred an early summer image before completing their first annual evaluation of the lease, and another image at the end of the grazing season to evaluate the success of the earlier management plan after the cattle had been taken off the lease.

The success of the project showed the importance of close cooperation and interaction between the government field staff, private ranchers and the remote sensing specialists.

ORDERING INFORMATION

Ordering of rangeland enhancements is designed with the user in mind - straightforward. An up-to-date list of Landsat imagery available for enhancement can be obtained from Distribution Services, Alberta Energy & Natural Resources. Using such a list, persons can place orders for imagery through Distribution Services who, in turn, pass these orders to the Alberta Remote Sensing Center. Image tapes of spring and fall Mixedgrass Prairie regions of Alberta are purchased from the Prince Albert Satellite Station, and using a computerized image analysis system, the Center generates color negatives according to a customer's requirements (location, date, scale). The negatives are returned to Distribution Services for processing into positives and then passed on to the customer. Full-size sample image enhancements are shown as Figures 6,7 More specific ordering information and current price schedules are available through provincial map and photo distribution centres:

Alberta Energy & Natural Resources
Distribution Services
3rd Floor, Sun Centre
530 - 8th Street, South
LETHBRIDGE, Alberta T1J 2J8
Phone: 403/329-5424

Alberta Energy & Natural Resources
Distribution Services
2nd Floor, North Tower, Petroleum Plaza
EDMONTON, Alberta T5K 2G6
Phone: 403/427-3519

Conventional Landsat imagery in various products and computer compatible tapes may be purchased from:

Prince Albert Satellite Station
P.O. Box 1150
PRINCE ALBERT, Saskatchewan S6V 5S7
Phone: 306/764-3602

INTERPRETATION TRAINING

The Alberta Remote Sensing Center will, on request, provide advice, assistance and training in the interpretation of enhanced Landsat images. Workshops for ranchers, government agencies and industry have been conducted in Lethbridge and Medicine Hat. Similar training sessions will be carried out, on request, in any part of the province.